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Non-tariff measures and productivity of Ukrainian food-processing firms

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Abstract

Using detailed data on veterinary, ecological, sanitary, phytosanitary and mandatory certification measures, this paper studies the effect of non-tariff measures (NTMs) on firm productivity in the food-processing industry through forward and backward linkages. Using quantity and value of output at product level, we calculate and compare quantity- and revenue-based measures of total factor productivity (TFP). Exploiting the episode of NTM liberalisation in Ukraine in 2008–2012, we find that NTMs on intermediate inputs have a negative effect on quantity-based TFP. Other trade policy variables, including input tariffs and output NTMs also negatively influence productivity. The effect on the revenue-based TFP is weaker due to price and quality adjustments. Interacting changes in input NTMs with import intensity prior to trade liberalisation, we find that firms that used imported inputs more intensively tend to have lower long-run TFP growth.

KEYWORDS
food industry, non-tariff measures, production function, productivity, TFP

JEL CLASSIFICATION
L66; Q17; Q18

1 | INTRODUCTION

Non-tariff measures (NTMs) have always been an essential part of the trade policy toolbox. However, because of substantial multilateral tariff reductions, they have replaced tariffs as the primary trade policy tools effects (Goldberg & Pavcnik, 2016). Growing public concerns about health and food safety have stimulated governments around the world to regulate food quality and safety by means of sanitary and phytosanitary (SPS) measures, product licensing and certification, and technical barriers to trade (TBT).

However, there are concerns that NTMs are protectionism in disguise, curbing product variety and making goods more expensive.[1] The introduction of NTMs may lead to a reduction in within-firm productivity by limiting the set of available intermediate inputs, equipment and technologies. The mechanism of the productivity decline works through the backward or forward linkages. The backward linkages cause a reduction in input variety as in Ethier (1982) or reduce the feasibility of certain ingredients or technologies, which leads to a less efficient mix of inputs. The productivity decline may also arise from forward linkages in the form of a lack of competition in the good's final markets, resulting in X-inefficiency (Corden, 1974) and scale effects (Helpman & Krugman, 1985; Krugman, 1979).

This paper investigates the effect of NTMs on within-firm productivity in the food-processing industry through the forward and backward linkages. The positive effects of trade liberalisation (mostly measured by import tariff reduction) on productivity have already been established (Amiti & Konings, 2007; Halpern et al., 2015; Kasahara & Rodrigue, 2008; Khandelwal & Topalova, 2011). The reduction in output tariffs has also been shown to have a positive, but weaker and less robust effect on productivity (Amiti & Konings, 2007; Pavcnik, 2002). In the food industry, greater competition in imported intermediate inputs boosts the productivity of food producers (Olper et al., 2017). However, little is known about how productivity is influenced by NTMs. It is important that this knowledge gap be filled because of the increasing rates of NTM protection, which are high compared to the most favoured nation (MFN) tariff rates. For example, in 2004, the average import-weighted *ad valorem* equivalent of NTMs was 10%, while the average import weighted *ad valorem* tariff was only 3.7% and by 2017 declined to 2.6%.[2] NTMs have also become more prominent due to their more frequent use (WTO, 2012), a shift that goes against the trend for multilateral and regional tariff liberalisation.

For several reasons, it is somewhat challenging to analyse the effect of an NTM, especially for food products. First, its opposite impacts on the demand and supply sides mean that it is *a priori* ambiguous. From the demand side, stricter regulations send a signal to consumers about the higher quality and safety of food products, which could stimulate consumer demand. This demand shock, if not appropriately controlled for, would increase the revenue-based measure of TFP, falsely signalling increased productivity (De Loecker et al., 2016; Foster et al., 2008; Kugler & Verhoogen, 2012). From the supply side, NTMs may reduce foreign competition and restrict access to imported inputs. However, they may also induce firms to improve quality (Bas & Strauss-Kahn, 2015; Curzi et al., 2015; Fan et al., 2015b; Hallak & Sivadasan, 2013; Halpern et al., 2015) with ambiguous implications for firm and industry performance. It is also challenging to study the effect of NTMs due to the difficulties of obtaining reliable and accurate measures (Goldberg & Pavcnik, 2016).

[1] See Swinnen and Vandemoortele (2011) for a political economy model of food standards.

[2] The *ad valorem* equivalents of non-tariff barriers are estimated by Looi Kee et al. (2009). Data on *ad valorem* applied tariffs are from the World Bank.

The literature on NTMs is mostly focused on their effects on trade, typically finding a negative overall effect (Disdier et al., 2008; Otsuki et al., 2001).[3] The effect is heterogeneous along various degrees of aggregation and margins of trade, including at the product level, the firm level and the country level (Fiankor et al., 2020). Crivelli and Gröschl (2016) find a negative impact of sanitary and phytosanitary (SPS) measures on the extensive margins of trade, but positive on the intensive margins. Looking at the Peruvian food industry firms, Curzi et al. (2020) find that NTMs significantly limit exports at extensive and intensive margins. Movchan et al. (2020) find that for Ukrainian food industry firms NTMs in upstream industries lead to higher export prices and higher quality of exported food products. The effect of NTMs on exports depends on the absorptive capacity of firms. Anders and Caswell (2009), investigating the effect of a Hazard Analysis Critical Control Points (HACCP) food safety standard on seafood imports, find a negative trade effect for developing countries and a positive effect for developed countries. The literature also documents an ambiguous effect on consumers and producers. Xiong and Beghin (2014) disentangle the effects of a specific NTM, a maximum residue level (MRL), to confirm that the demand effect of food safety on exporting is positive whereas the supply side effect is negative. Moreover, exporters from developing countries are more impacted by the MRL. Beghin et al., (2015) further find that NTMs have a trade-facilitating effect on a large number of products. Finally, there is a stream of literature that emphasises the benefits of NTM harmonisation across countries. For instance, Chen and Mattoo (2008) document that regional agreements that harmonise NTMs are beneficial for bilateral trade.

Our analysis is focused on the impact of domestic NTMs on the productivity of domestic firms. This question is important for policy-makers who have a direct influence on domestic NTM regulations and are tasked with drawing on a wide variety of NTM tools to design the optimal policy. Our paper contributes to the literature in several ways. First, it identifies a causal impact of NTMs on productivity by exploiting as a source of exogenous variation the 2008–2012 episode of NTM liberalisation following Ukraine's WTO accession. Second, it improves on the measurement of NTMs, which are recorded from legal texts at the most disaggregated level and capture the period of very important changes in the approach to non-tariff measures, when Ukraine decided to move away from the Soviet system of mandatory standards and quality control (GOST) to the modern WTO system, which is also compatible with the European Union (EU) standards. We use a unique dataset of Ukrainian NTMs, which directly records veterinary, sanitary, phytosanitary, ecology controls and mandatory certifications from the Ukrainian legal texts at the 10-digit classification of product lines. These measures are applied to imported goods by the customs border control system. We combine the NTM data with the product-level data for the Ukrainian food producers (NACE 1.1 Section 15: Manufacture of food products and beverages). We also incorporate recent advances in the literature on production function estimation and demonstrate that separating demand and supply shocks is very important for the analysis of the impact of policy on productivity. We observe both the prices and quantities of output; hence, we are able to separate the productivity effects of NTMs from their demand side effects. Using an approach similar to De Loecker et al. (2016), we compute and contrast productivity measures based on revenue- and quantity-based production function estimations. Third, we consider both the average effect of all types of NTM and the effects of NTM components, including sanitary, phytosanitary, veterinary, ecological and mandatory certification measures that are imposed against upstream inputs and downstream outputs.

[3]See also Santeramo and Lamonaca's (2019) meta-analysis of studies on the impact of NTMs in agri-food trade.

The rest of the paper is organised as follows. Section 2 discusses changes in NTMs in Ukraine in 2007–2013. Section 3 introduces a model. Section 4 presents the data. Section 5 discusses our empirical methodology. In particular, it shows TFP estimation and construction of input and output NTMs. Section 6 presents the main results. Section 7 concludes.

2 | NON-TARIFF MEASURES

2.1 | Mechanisms of NTM impact on productivity

The mechanisms of the impact of NTMs on firms are broader than the mechanisms of the impact of tariffs. Akin to tariffs, NTMs influence the importing of goods in upstream and downstream industries at extensive and intensive margins by increasing the fixed and variable trade costs. These include the costs of compliance with the regulations at the production stage, the costs of monitoring and verifying the compliance, and the costs of inspections at the border. In the downstream industries, elimination of NTMs would increase competition, leading to the Melitz selection mechanism (Melitz, 2003) at extensive margins, a more efficient allocation of resources due to the expansion of more productive firms, a reduction in operational slack, and X-efficiency gains. In the upstream industries, abolishing NTMs would result in lower costs and a wider variety of inputs available to the local firms. This would increase within-firm productivity due to a more expansive range of imperfect input substitutes, learning by importing, and lower cost per unit of quality. However, the quality of inputs may potentially be lower.

In addition, NTMs may ban certain technologies and ingredients, such as chlorinated chickens, antibiotics in meat, and products that contain genetically modified organisms (GMOs). In this way, NTMs are similar to import quotas and import prohibitions in that they directly regulate the quantity of certain inputs, inducing firms to choose the optimal input mix under an additional set of constraints. Importantly, these measures not only influence the cost of production but also set requirements for the quality of the final goods, and these higher health and safety standards may in turn positively impact consumer demand. Therefore, NTMs may simultaneously shift supply and demand curves in the upstream industries.

To conclude, productivity gains may emerge from liberalising NTMs because of the tighter competition in final goods, greater variety in intermediate imports, learning from importing, and scale effects. However, it also may result in lower demand for the final output, due to lower standards for quality and health.

2.2 | NTM liberalisation in Ukraine

In the study, we focus on the transformation of Ukraine's NTMs during 2007–2013, that is, starting the year before Ukraine joined the WTO, to analyse the changes that occurred after the country joined this international organisation. This period embraces the results of almost two decades of reform efforts aimed at replacing the old Soviet system of mandatory standards (GOSTs) with the WTO-compatible system of product safety controls. To measure NTMs and document the process of liberalisation, we use a unique database of Ukrainian NTMs in 2007–2013. It contains information on NTMs designed to safeguard the lives and health of people, animals, and plants. More precisely, we focus on five types of controls:

- Veterinary control aimed at preventing the spread of animal-origin diseases;
- Phytosanitary control aimed at preventing the spread of pests and plant diseases;

- Sanitary and epidemiological control aimed at preventing the spread of infectious diseases and testing the compliance of sanitary rules with the ultimate goal of protecting people's lives;
- Ecological control aimed at protecting the environment;
- Mandatory certification aimed at testing compliance with mandatory standards that, in their turn, are aimed at protecting the lives and health of people, ensuring technical compatibility, controlling labour safety, and so on.

These types of controls have been specified through a variety of legislation and are implemented by different state agencies. NTM provisions are taken directly from Ukrainian legal texts. Table A2 in the Online Appendix identifies the legal sources. Data is collected at the 10-digit classification of product lines (TS10) and by different types of NTMs. At the product-type level, an observation is coded as a binary variable, taking the value of 1 if type k NTM is applied and 0 otherwise. Data are aggregated at the level of HS 6-digit product lines, as the share of lines with NTMs, thus:

$$NTM_{HS6,t}^{k} = \frac{1}{N_{HS6}} \sum_{TS10 \in HS6} NTM_{HS10,t}^{k} \tag{1}$$

where $k = \{Veter, \ Ecol, \ Sanit, \ Phyto, \ Cert\}$, $NTM_{HS10,t}^{k}$ is a binary NTM indicator at 10-digit level and $N_{HS6}$is the number of TS10-digit lines within an HS 6-digit category. This measure of NTMs is called a frequency of NTM index. Its advantage is simplicity and comprehensive coverage of all product lines. Its disadvantage is that it does not differentiate NTMs by their stringency. However, given the frequency indicator, the stringency can be inferred by looking at its impact on variables of interest, such as productivity, trade or quality.

To combine trade data with firm-level data on productivity and size, we use the HS to ISIC and ISIC to NACE concordances available from the World Integrated Trade Solutions (WITS) website and the Eurostat/RAMON service. We aggregate NTM measures to the level of NACE1.1 3-digit food sub-industries, computing the simple averages of all the HS 10-digit NTMs. There were almost no changes in the NTM legislation prior to 2008. Therefore, we take 2007 as a pre-liberalisation starting point, being the last year before the episode of trade liberalisation.

Despite the fact that NTMs should be equally applied to local and foreign producers, these measures are a part of the customs border control system and are therefore applied only on imported goods.[4]

Figure A1 in the Online Appendix illustrates the frequency index of Ukraine's NTMs in 2007–2013. It clearly highlights one of the key problems of the old system: the excessive duplication of controls, thereby amplifying the control functions of the state agencies. In 2007, most of the food industry's subsectors faced duplication of controls, whereas by 2013 the controls had been streamlined and duplication reduced. In particular, in line with Ukraine's WTO commitments, the mandatory certification of food products was gradually eliminated, while the task of ensuring food safety was placed under sanitary and, if relevant, veterinary controls. This change was especially pertinent to beverages, dairy and fish products, fruits and vegetables, and oils and fats. Other types of control were also streamlined, with the most visible change being experienced by the prepared animal feed sector, where only veterinary control remained. For more detailed information by different food sub-industries, please refer to Movchan et al. (2020).

[4]In theory, the same standards are applied to local producers. However, it is highly unlikely that domestic controlling authorities follow procedures that are as strict as those of the customs border controls, and even if this were the case, importers are subject to double regulations—within their home country and in Ukraine. This imposes additional costs on importers.

These changes allowed a reduction in the total number of NTMs that applied to Ukraine's food sector. However, the duplication of controls was not completely removed. For example, many animal origin products (meat, fish, dairy) are subject to both veterinary and sanitary controls, while for grain, mill and starch products, sanitary and phytosanitary controls are only partially duplicated.

3 | THEORETICAL FRAMEWORK

3.1 | Productivity and imported intermediate inputs

Consider a firm with a Cobb–Douglas production function $Q = \Phi_Q K^{\beta_K} L^{\beta_L} M^{\beta_M}$, where Φ_Q is the total factor productivity, which is *ex ante* exogenous to the firm and randomly drawn from an *ex ante* known distribution after paying an entry fixed cost; K is capital; L is employment; and M is aggregate intermediate input. K is predetermined, while L and M are variable inputs chosen conditionally on Φ. We also assume that $\beta_K + \beta_L + \beta_M = 1$.

The firm operates in a small open economy, taking input prices as given. The final good industry is monopolistically competitive, with each firm producing a distinct variety. Intermediate inputs can be sourced domestically or imported and are combined into the aggregate intermediate input

$$M = \left(\int_{j \in J} x\,(j)^{\rho}\, dj + \int_{j \in J*} \left[\Lambda\,(j)\, x^*\,(j) \right]^{\rho} dj^* \right)^{1/\rho} \tag{2}$$

where $0 < \rho < 1$. Inputs are horizontally and vertically differentiated. Horizontally differentiated input varieties are imperfect substitutes with elasticity of substitution $\sigma_M > 1$, which is related to ρ as given by $\sigma_M = 1/(1-\rho)$. J is a set of domestic varieties and J^* is a set of imported varieties. x and x^* are quantities of domestic and imported inputs. Inputs are also vertically differentiated. $\Lambda(j) \geq 1$ is a measure of input quality. We assume that domestic inputs are of the same baseline quality $\Lambda(j) = 1\ \forall j \in J$, and that the marginal cost of producing one unit of intermediate input of the baseline quality is 1. Imported inputs vary in quality and are subject to non-tariff (NTM) and tariff (t) regulations. Policy function $\tau(NTM, t) \geq 1$ describes the cost that trade policy imposes on imported intermediate inputs with $\frac{\partial \tau}{\partial NTM} > 0$ and $\frac{\partial \tau}{\partial t} > 0$. Assuming the input markets are perfectly competitive, $p^*(j) = \Lambda(j) \times \tau(NTM(j), t(j))$ is the price of a unit of intermediate foreign input, while $p_D = 1$ is the price of a unit of domestic intermediate input.

Motivated by the fact that not all domestic firms use imported inputs and often switch import status in and out (Halpern et al., 2015), we assume that importing requires paying a fixed cost, which incrementally increases with the number of imported inputs. Thus, importing j inputs requires paying $F = j \times f$, which is due every period. We also assume that domestic varieties do not require the payment of these fixed costs.

Suppose that the mass of domestic and foreign intermediate inputs used by a firm are n and n^*, respectively.[5] In equilibrium, any firm at any *ex ante* productivity level uses all domestic inputs: $n = J$. We consider a symmetric case where all imported inputs are of the same quality Λ and have the same price p_m^*. The extensive margin of imports, $n^* \leq J^*$, depends on the productivity level. Consequently, for a firm that uses only domestic inputs, $M = J^{1/\rho} \times \overline{x}$ and for an importing firm, $M = (J + \Lambda^{\rho} n^*)^{1/\rho}\, \overline{x}$. An importing firm would have a productivity advantage over a firm with the same productivity level that uses only domestic inputs. A firm that uses only domestic inputs would have total factor productivity:

[5] We suppress the firm index for clarity of presentation.

$$A(\Phi_Q, n) = \Phi_Q \times n^{\beta_M/\rho}$$

For an importing firm, and ignoring the fixed costs of importing, total factor productivity is given by:

$$A^*\left(\Phi_Q, n, n^*\right) = \Phi_Q \times (n + \Lambda^\rho \times n^*)^{\beta_M/\rho}$$

A number of imported inputs n^* is further determined as follows:

$$n^*(\Phi_Q, NTM(j), t(j)) = \underset{j}{arg\,max}[\pi(\Phi_Q, j, NTM(j), t(j)) - j \times f]$$

where $\pi(.)$ is the one-period profit of a firm with the initial productivity draw Φ_Q, subject to trade policy $NTM(j), t(j)$. j is the number of imported intermediate inputs.

Importantly, since the profit function increases in *ex ante* productivity, there is an import productivity threshold $\tilde{\Phi}_Q$, such that $n^*(\tilde{\Phi}_Q) = 1$ and $n^*(\Phi_Q) = 0\ \forall \Phi_Q < \tilde{\Phi}_Q$. The productivity advantage of an importer with *ex ante* exogenous productivity draw $\Phi^1_Q > \tilde{\Phi}_Q$ over a non-importer with productivity $\Phi^0_Q < \tilde{\Phi}_Q$ would arise from three sources: (i) self-selection due to the initial exogenous productivity draw, (ii) a greater variety of intermediate inputs, and (iii) a better quality of imported inputs:

$$\Delta Prod = \frac{\Phi^1_Q}{\Phi^0_Q} \times \left[1 + \Lambda^\rho \frac{n^*}{J}\right[^{\beta_M/\rho} \tag{3}$$

3.2 | Marginal cost and NTMs

We do not observe the quality of inputs in our sample. However, we can use information about the material costs to account for it. Solving the cost minimisation problem for intermediate inputs yields the following optimal inputs:

$$x = \left(1/P_M\right)^{1/(1-\rho)} M$$

and

$$\Lambda x^* = \left(p^*_m/(\Lambda P_M)\right)^{1/(1-\rho)} M$$

where the unit cost of input M is given by the following price index:

$$P_M = \begin{cases} J^{1/(1-\sigma_M)} & if\ \ x^* = 0 \\ \left(J + \left(p^*_m/\Lambda\right)^{1-\sigma_M} n^*\right)^{1/(1-\sigma_M)} & if\ \ x^* > 0 \end{cases}$$

An importing firm has a productivity advantage over a company with the same *ex ante* exogenous productivity Φ that does not import intermediate inputs as long as the input markets are perfectly competitive and $\tau > 1$:

$$\Delta Prod = \left[1 + \left(\frac{p^*_m}{\Lambda}\right)^{1-\sigma_M} \frac{n^*}{J}\right]^{-1/(1-\sigma_M)} = \left[1 + (\tau(NTM, t))^{1-\sigma_M} \frac{n^*}{J}\right]^{-1/(1-\sigma_M)} > 1 \tag{4}$$

This advantage increases with lower τ and also with a larger number of importer inputs, n^*. Therefore, the model predicts that introducing non-tariff measures on imported inputs increases the marginal cost of production and lowers the productivity of an importing firm. If quality $\Lambda(j)$ differs across importers and the NTM imposes a minimum quality standard such as $\Lambda \geq \Lambda_{MIN}$, NTMs would also limit the number of importers $\partial n^*(\Lambda_{min})/\partial\Lambda_{min} < 0$, which would similarly reduce productivity.

Our model assumes that the prices of intermediate inputs fully reflect quality and trade costs since the input markets are perfectly competitive. If we relax this assumption, we may observe that importers do not have a cost advantage as long as n^* is low and $p^*(j)?\Lambda(j) \times \tau(NTM(j), t(j))$.[6] Both are more likely when the domestic economy has high trade barriers, which leads to monopolised intermediate input markets with fewer competitors. For two sources of heterogeneity—productivity and quality—this would also depend on the trade-off between the quality-sorting versus efficiency-sorting (see Manova and Zhang, 2012, for stylised facts and Fan et al., 2015a, for an application).

4 | DATA

The data for the project come from several sources. To obtain the dependent variable, total factor productivity (TFP), we used the statistical statements of commercial firms in 2002–2013 (TFP sample), available from the State Statistical Service of Ukraine (Ukrstat). In particular, Financial Results Statements provide data on revenues less indirect taxes, which is a revenue-based measure of output, and material costs, which is a measure of the cost of inputs. The Balance Sheet statements provide the value of fixed assets, our capital measure. Full-time employment equivalent, our labour measure, is also from the Balance Sheet statements. Investments in fixed assets were taken from the Enterprise Performance Statements. It should be noted that the requirement to provide all this information to Ukrstat is only mandatory for relatively large firms; after 2012, the reporting from small firms was simplified in that they do not have to include information on material costs and investments. To deal with this problem, we restrict the sample to only firms with at least 10 employees and positive values of output and capital.

The revenue-based output measure was deflated by a two-digit sector deflator of manufacturing output, whereas material costs, investments and capital measures were deflated by the PPI index, both of which were acquired from Ukrstat. These data are used to obtain the revenue-based estimates of TFP. We then draw on detailed annual statements of firm-level manufacturing output by product groups with Classification of Products by Activity (CPA) at the six-digit level. These statements contain information on quantities and prices, from which we calculate firm-level output price, P, which is used to compute firm output $Q = R/P$ where R is the revenue-based output. We use $\ln Q$ as the dependent variable to estimate the quantity-based production function from which we calculate the quantity-based TFP. Computing P is straightforward for firms that produce only one variety of product, which we call mono-product firms. For multiproduct firms, which produce many different outputs, a CES price index was computed (see the next section for a more detailed discussion of this). The process of price determination involves dropping extremely high and low values on the understanding that aggregation at the level of six digits covers substantial heterogeneity between physical outputs.[7]

[6]For instance, there is evidence of less than 100% pass-through of lower tariffs on prices De Loecker et al. (2016).

[7]We dropped 4540 prices that were below 5th and above 95th percentiles of price distributions in each year.

TABLE 1 Descriptive statistics

	2007	2008	2009	2010	2011	2012	2013
Output, '000 UAH	31,484	40,161	40,042	44,764	48,390	58,161	57,755
Capital, '000 UAH	6,666	7,896	8,269	8,098	8,636	10,020	11,797
Mat. Costs, '000 UAH	15,344	17,856	18,208	21,478	22,590	25,489	27,406
Mat. Investments, '000 UAH	2,784	3,147	2,302	1,737	2,531	2,483	2,712
Employment	235	252	253	266	279	287	289
Share of exits	0.15	0.15	0.14	0.10	0.13	0.14	0.00
Share of exporters	0.30	0.32	0.38	0.38	0.40	0.42	0.43
Share of importers	0.27	0.28	0.27	0.29	0.32	0.34	0.39
Share of monoproduct firms	0.29	0.28	0.31	0.32	0.32	0.24	0.23
N	1,921	1,658	1,494	1,322	1,286	1,244	1,168

All monetary variables are deflated with PPI.

To analyse the effect of NTM on productivity we look only at the period of 2007–2013 (NTM sample) because there is no variation in NTMs prior to 2007. The input requirements for each food sub-industry was taken from 2005 Input-Output tables.[8] We also use correspondence tables between HS and NACE1.1 classification, available from Eurostat/RAMON service, to discover the input requirements for each sector.[9] Another important explanatory variable, the measure of most favoured nation (MFN) tariff, is taken directly from the World Integrated Trade Solution (WITS) database, hosted by the World Bank.

The main data set is combined with the Customs data to extract the importer/exporter status of each firm. Table 1 presents the summary statistics. Overall, the number of firms in our NTM sample decreased from about 1900 in 2007 to 1200 in 2013. During the 2007–2013 period, an average firm almost doubled its output, capital and material cost without a noticeable increase in employment. The food-processing industry became more open, with an increase in the share of exporting firms from 30% to 43%, and an increase in the share of importing firms from 27% to 39%.

5 | METHODOLOGY

The empirical strategy proceeds in two stages. First, TFP is computed based on the production function estimation. Second, TFP estimates are regressed on measures of NTM intensities and controls.

5.1 | Revenue-based and quantity-based estimates of productivity

Foster et al. (2008) identified a common problem in empirical research when the productivity estimation is based on revenue $R = P \times Q$. The standard procedure of estimating the revenue-based production function leads to TFP capturing confounding effects of prices, quality and quantity. When a researcher has observations on both prices and quantities of output, it is possible to estimate the production function based on physical outputs. However, there is a problem with aggregation when a firm produces multiple outputs. De Loecker et al. (2016) developed a methodology for estimating the productivity of firms when the quantities and prices of outputs are observed but the allocation of inputs across different outputs is unknown. In particular, they suggest estimating a production function based on a sample of mono-product firms. An alternative strategy would be to compute a firm-level aggregate output and price index. This aggregate firm-level output can be used as the dependent variable in the estimation of the production function.

We implement estimation of the production function for both mono- and multi-product firms. We do the latter to ensure that the mono-firm sample does not introduce a selection bias into our later analysis. We also report and contrast the results for revenue- and output-based productivity estimates. A quantity-based production function for a firm i from food sub-industry j at time t is given by:

$$Q = \Phi_Q K^{\beta_K} L^{\beta_L} \tilde{M}^{\beta_M} \tag{5}$$

which differs from the revenue-based production function:

$$R = \Phi_R K^{\alpha_K} L^{\alpha_L} \tilde{M}^{\alpha_M} \tag{6}$$

[8]In 2005, the extended IO tables were issued by Ukrstat, which covered 52 tradable goods sub-industries and 80 sub-industries in total. The 2005 IO table is available at http://www.ukrstat.gov.ua/operativ/operativ2009/vvp/an_tvv/IOT05exp.rar

[9]A description of this matching procedure is available from the authors upon request.

For mono-product firms, estimating the quantity-based production function is straightforward because we have the data on the quantity of output in kilograms. Now, consider a multi-product firm with the set of outputs and prices $\{p_i, q_i\}$, $i = 1, \ldots, N$. The firm produces goods that are substitutes with constant elasticity of substitution σ. We define a firm-level price index:

$$P^{1-\sigma} = \sum w_i p_i^{1-\sigma}$$

where $w_i = \frac{p_i q_i}{R}$.[10] We further define the quantity of output for a multi-product firm as $Q = R/P$.

Note that the theory-based measure of material cost in equaiton (2) differs from the empirical measure, which is the total expenditures on goods and services in thousands of Ukrainian hryvnas (UAH) deflated by the common production price deflator, $\overline{P}_M$. First, it is not a purely quantity-based measure since $\tilde{M} = P_M M / \overline{P}_M$. Second, it does not capture the variety and quality of inputs as long as the price of inputs does not fully reflect quality and trade costs.

5.2 | Estimation of production function and TFP

We define the food industry as all firms reporting their main economic activity to be the manufacture of food products and beverages (NACE1.1 Section 15). Total factor productivity is estimated separately for each 3-digit NACE1.1 group, which we refer to as the nine food sub-industries (thus, the meat sub-industry, fish sub-industry, etc.)

Table 2 presents point estimates of the coefficients of production functions estimated according to Levinsohn and Petrin (2003; henceforth LP), with material cost as a proxy for productivity on both the full sample (Panel A) and on the sample of mono-product firms alone (Panel B).[10] The coefficients of the revenue-based production function are reported to the left of the table, while the coefficients of the quantity-based production function are reported to the right of the table.[11]

We compute TFP, using the quantity-based coefficients estimated on the sample of mono-product firms as the baseline results. The quantity-based TFP (QTFP) is computed as given by

$$\ln\Phi_{Q,ijt} = \ln Q_{it} - \hat{\beta}^j_K \times \ln K_{it} - \hat{\beta}^j_L \times \ln L_{it} - \hat{\beta}^j_M \times \ln M_{it} \tag{7}$$

The revenue-based TFP (RTFP) is calculated as given by:

$$\ln\Phi_{R,ijt} = \ln R_{it} - \hat{\alpha}^j_K \times \ln K_{it} - \hat{\alpha}^j_L \times \ln L_{it} - \hat{\alpha}^j_M \times \ln M_{it} \tag{8}$$

We further compute sub-industry level QTFP and RTFP, by calculating output-weighted averages by each food sub-industry and year. Figure A2 in the Online Appendix shows the dynamics of TFP in 2002–2013. Table 3 reports average productivity growth based on QTFP

[10]We take σ = 5 for our main result, as is common in the literature (Head and Mayer, 2014). We also perform robustness checks with other values of σ, which do not alter our conclusions. The results are available upon request.

[10]We implement LP using STATA command prodest (Rovigatti and Mollisi, 2018).

[11]We also have estimated total factor productivity (TFP) using the Olley-Pakes (OP) method (Olley and Pakes, 1996), Ackerberg-Caves-Frazer (ACF) method (Ackerberg et al., 2015), and ACF with material cost as the proxy for productivity (ACF LP). These alternative TFPs are used for robustness checks.

TABLE 2 Production function estimation: Levinsohn and Petrin (2003)

	Revenue production function				Quantity production function			
Industry	α_K	α_L	α_M	N	β_K	β_L	β_M	N
A. All firms								
Meat products	0.043	0.147	0.783	2726	−0.051	0.306	0.72	1723
	(0.05)	(0.032)	(0.044)		(0.088)	(0.062)	(0.084)	
Fish products	−0.117	0.25	0.769	504	0.077	0.378	0.504	329
	(0.094)	(0.088)	(0.08)		(0.148)	(0.241)	(0.132)	
Fruit and vegetables	0.058	0.265	0.579	1221	0.084	0.396	0.514	723
	(0.061)	(0.053)	(0.047)		(0.113)	(0.121)	(0.103)	
Vegetable and animal oils and fats	0.152	0.204	0.562	817	0.035	0.491	0.627	473
	(0.064)	(0.075)	(0.049)		(0.072)	(0.141)	(0.09)	
Dairy products	0.063	0.241	0.683	3263	−0.013	0.182	0.756	2043
	(0.031)	(0.046)	(0.045)		(0.037)	(0.097)	(0.095)	
Grain, mill products, starch products	0.065	0.251	0.611	6072	0.055	−0.075	0.668	4067
	(0.017)	(0.019)	(0.042)		(0.068)	(0.062)	(0.082)	
Prepared animal feeds	0.184	0.205	0.619	651	0.059	0.469	0.609	373
	(0.061)	(0.05)	(0.089)		(0.069)	(0.118)	(0.067)	
Other food products	0.055	0.201	0.501	2691	0.226	0.371	1.097	1553
	(0.026)	(0.038)	(0.033)		(0.202)	(0.204)	(0.222)	
Beverages	0.024	0.19	0.783	3500	−0.03	0.151	0.868	1913
	(0.022)	(0.035)	(0.034)		(0.15)	(0.179)	(0.15)	
B. Monoproduct firms								
Meat products	−0.068	0.191	0.584	274	0.188	0.276	0.342	251
	(0.147)	(0.054)	(0.127)		(0.127)	(0.174)	(0.179)	
Fish products	−0.076	0.37	0.775	171	0.029	0.393	0.794	159
	(0.103)	(0.092)	(0.091)		(0.123)	(0.2)	(0.193)	

TABLE 2 (Continued)

Industry	Revenue production function				Quantity production function			
	α_K	α_L	α_M	N	β_K	β_L	β_M	N
Fruit and vegetables	0.277	0.219	0.55	246	0.238	0.138	0.523	225
	(0.153)	(0.097)	(0.136)		(0.268)	(0.222)	(0.166)	
Vegetable and animal oils and fats	−0.016	0.337	0.707	131	−0.1	0.669	0.497	126
	(0.091)	(0.161)	(0.106)		(0.24)	(0.265)	(0.229)	
Dairy products	−0.002	0.282	0.729	469	−0.158	−0.024	1.049	423
	(0.05)	(0.053)	(0.053)		(0.131)	(0.18)	(0.132)	
Grain, mill products, starch products	−0.012	0.239	0.727	961	−0.045	0.394	0.604	933
	(0.035)	(0.053)	(0.064)		(0.059)	(0.089)	(0.049)	
Prepared animal feeds	0.11	0.161	0.688	283	0.079	0.509	0.599	254
	(0.054)	(0.062)	(0.074)		(0.076)	(0.138)	(0.098)	
Other food products	−0.094	0.214	0.596	476	0.116	0.18	0.746	446
	(0.081)	(0.081)	(0.079)		(0.161)	(0.254)	(0.205)	
Beverages	0.045	0.188	0.745	1115	0.152	−0.185	0.764	994
	(0.045)	(0.056)	(0.07)		(0.228)	(0.18)	(0.318)	

This table presents estimation of the parameters of revenue (left panel) and quantity (right panel) production functions for nine food sub-industries estimated by (Levinsohn & Petrin, 2003) method using all firms (Panel A) and mono-product firms (Panel B). In addition to the estimated parameters, it reports number of observations *N*, used for each estimation. Bootstrapped standard errors are presented in parentheses.

TABLE 3 Productivity growth in food industry in Ukraine, 2007–2013

	Year							
Industry	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Meat products	1.6	25.6	−14.3	−4.4	4.7	4.8	35.1	10.7
Fish products	6.7	11.2	−0.4	−0.8	1	2.9	39.5	10.2
Fruit and vegetables	39.9	1.7	−19.3	7.6	4.6	20.2	18.8	11.6
Vegetable and animal oils and fats	−70.7	38.8	40.3	−30.2	6	14.8	15.4	7.2
Dairy products	−10.8	15.6	−2.4	−3	3.5	14	−0.7	2.8
Grain, mill products, starch products	3.7	7.9	1.9	0.1	3.8	3.6	12.7	4.9
Prepared animal feeds	−8.2	18.2	8.7	−5.4	−1.8	−6.8	7.2	0.8
Other food products	−31.7	8.3	5.1	1.8	5.7	−17.6	−5.6	−4.5
Beverages	1.5	4.3	−0.2	1.2	2.9	31.6	−5.6	6.4
Total	−12.9	16	6.8	−6.7	4.3	9.6	7	4.4

Growth rates in percent are computed as an output weighted average TFP growth. TFP is calculated based on the production function estimates for the quantity-based sample of mono-product firms using Levinsohn and Petrin's (2003) method.

by food sub-industry in 2007–2013, when the average productivity growth was 4.4% per year. Fruit and vegetables, meat and fish products were among the sub-industries with the fastest productivity growth, and dairy products, prepared animal feeds had slower productivity growth, whereas productivity in other product goods declined over 2007–2013.

5.3 | Trade protection measures

5.3.1 | Input NTMs and tariffs

As is standard in the literature (Amiti & Konings, 2007), we calculate input NTMs and input MFN tariffs at the sub-industry level. These vary across sub-industries and over time but are common to all firms within the sub-industry. The underlying assumption is that all firms within a food sub-industry use similar technologies and require similar inputs; hence, they are subject to the same regulatory policy that, from the firm's viewpoint, is exogenous. At the same time, we exploit an important dimension of heterogeneity across firms that is related to their productivity, which is the fact that some firms use imported inputs whereas others use local inputs. This reflects endogenous decision-making due to firm-level heterogeneity.

Input NTM of type$k$, where $k = Veter,\ Ecol\ , Sanit,\ Phyto,\ Cert$and input MFN tariff in food sub-industry $j$at time $t$are computed as

$$inNTM_{jt}^{k} = \sum_{m} w_{jm}^{2005} \times NTM_{mt}^{k}$$

and

$$t_{jt}^{in} = \sum_{m} w_{jm}^{2005} \times t_{mt},$$

where m refers to industry which output is used as input in food sub-industry j production, NTM_{mt}^{k} is a share of HS6 product lines within the sub-industry $m$that are covered by NTM of type $k$at time t. $t_{m,t}$is a simple average MFN tariff rate, applied to all products imported to Ukraine within sub-industry m at time t.[13] w_{jm}^{2005} is a coefficient from the Ukrainian 2005 Input-Output table, which measures the share of the value of inputs from sub-industry m into the total inputs of sub-industry j.[14] We also construct the average input NTM protection index as given by:

$$inNTM_{jt} = \frac{1}{5}\sum_{k} inNTM_{jt}^{k},$$

which captures the average level of input NTM protection and allows us to evaluate the overall effect of NTMs on productivity.

Figure A3 in the Online Appendix presents dynamics of input NTMs by food sub-industries in 2007–2013. Sanitary measures dominated all food sub-industries starting in 2008. Veterinary controls were widely present for fish products and to a lesser extent for meat products. There was a rapid decline in the use of mandatory certifications and a general trend in the reduction of MFN tariffs.

5.3.2 | Output NTM and tariffs

We also construct industry-level indices of NTM and tariff protection for outputs by computing simple averages of NTM frequencies and MFN tariffs as follows:

$$outNTM_{jt}^{k} = \frac{1}{N_j}\sum_{HS6\in j} NTM_{HS6,t}^{k}$$

and

$$t_{jt}^{out} = \frac{1}{N_j}\sum_{HS6\in j} t_{HS6,t}$$

where N_j is the number of HS 6-digit product lines in the output of the sub-industry j. The mapping of HS 6-digit product lines into NACE1.1 sub-industries is performed using WITS correspondences tables. These indices measure the level of protection of firms in industry j against foreign competition. We also construct the overall output NTM protection index as given by:

$$outNTM_{jt} = \frac{1}{5}\sum_{k} outNTM_{jt}^{k}.$$

5.4 | Empirical specification

To investigate the effects of NTM liberalisation in 2007–2013 on firm productivity, we consider the following parametric specification:

$$\ln TFP_{ijt} = \gamma_0 + \gamma_1 \ln(1 + inNTM_{jt}^{k}) + \gamma_2 imp_{it} + \gamma_3 \ln(1 + inNTM_{jt}^{k}) \times imp_{it} + \gamma_4 \ln(1 + t_{jt}^{in}) + \gamma_5 \ln(1 + outNTM_{jt}^{k}) + \gamma_6 \ln(1 + t_{jt}^{out}) + \gamma_7 exp_{it} + \gamma_8 \ln L_{it} + \varphi_i + \delta_t + \delta_j + \varepsilon_{it} \quad (9)$$

[13]The mapping of HS 6-digit codes into NACE1.1 3-digit sub-industries is performed using consequent mappings of HS 6-digit codes into ISIC Rev.3 industries (available on World Integrated Trade Solution (WITS) website) and further mapping of ISIC Rev.3 into NACE1.1 sub-industries.

[14]The 2005 Input-Output table is the most detailed IO table available from the Ukrstat. 2005 weights precede the episode of changes in NTMs, so it does not cause endogeneity concerns. The source of variation in the NTM measure is the product-level changes to NTMs over time.

where firm i is from food sub-industry j. TFP_{ijt} is firm i's measure of productivity at time t. TFP is estimated by LP, but we also considered other methods, which generated the results described in the robustness section. $inNTM^k_{jt}$ is either the average or one of the five specific measures of input NTM protection in industry j at time t. We control for input tariffs $\ln(1 + t^{in}_{jt})$, as another form of protection against imported inputs. We also control for levels of industry protection using our output NTM and output tariff measures. imp_{it} and exp_{it} are binary variables taking values of 1 if a firm i imported or exported in year t and 0 otherwise. The interaction term $\ln(1 + inNTM^k_{jt}) \times imp_{it}$ is one of the variables of interest. A significant and negative γ_3 would suggest that importing firms are less productive due to more stringent NTMs. We also control for the firm size, with the natural log of employment. The error term has four components. First, the firm-specific term φ_i captures unobservable time invariant characteristics, such as random productivity draw *à la* Melitz, which does not depend on policy changes and economic shocks. Second, time effect δ_t captures macroeconomic shocks, such as the 2008–2009 financial crisis. The timing of this crisis coincided with the WTO accession of Ukraine, which makes it particularly difficult to disentangle the two effects. Third, we include a sub-industry fixed effect to capture differences in the productivity measures across sub-industries. These arise from the use of different units to measure output (e.g., tons in the meat sub-industry and litres in the beverages sub-industry). Since the sample firms can change the industry, it is possible to control for both firm fixed effects and industry fixed effects. Finally, an idiosyncratic error term ε_{it} is $iid: (0, \sigma^2_i)$.

6 | RESULTS

6.1 | Main results: Aggregate NTM measures

In our preferred specification, the dependent variable is quantity-based TFP computed using the production function coefficients for the mono-product firm sample, estimated by Levin-sohn and Petrin (2003).[12] Table 4 presents the main results. All regressions control for the firm size and have time, sub-industry and firm fixed effects. Column (1) reports a negative and significant effect of input NTM on productivity. A 1% increase in input NTM is associated with 1.2% lower TFP. We expect that input NTMs influence the productivity of importing firms more than they affect the productivity of non-importing firms. Adding an import control variable and an interaction of importing with input NTM in column (2) confirms this conjecture. For non-importing firms, a 1% increase in input NTM reduces productivity by 0.8% and is not statistically significant; however, importers experience an additional 0.9% reduction (thus, 1.7% reduction in productivity). This difference is statistically significant. The absence of a significant effect on non-importers indicates that the reduction in NTMs has a direct impact on firms that use intermediate inputs, but does not spill over to the entire industry. Moreover, food companies that import are 25.5% more productive than non-importers. This finding is consistent with the heterogeneous firms model and fixed costs of importing, such that only the most productive firms find it profitable to import intermediate inputs. In column (3) we control for input tariffs. The effect of input NTMs on importers remains negative and significant, while the effect of input MFN tariffs is negative but not significant. In column (4) we control for the level of protection against foreign competition accorded to final goods by adding output NTM and output MFN controls. Both input and output NTMs have negative effects on productivity, while the effect of input MFNs on importers turns more negative and significant. The size of the

[12] We also estimated the regression with TFP based on the sample of multi-product firms. The results are similar and do not change our main conclusions. The results are available upon request.

TABLE 4 Average NTM effect on productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Input NTM	−1.213*	−0.845	−0.832	0.812	0.897	1.406*
	(0.55)	(0.56)	(0.60)	(0.61)	(0.62)	(0.61)
Input NTM × Importer		−0.911**	−0.911**	−0.979**	−0.972**	−1.630**
		(0.33)	(0.33)	(0.33)	(0.33)	(0.31)
Input MFN			−0.019	−1.801**	−1.935**	−1.994**
			(0.59)	(0.65)	(0.65)	(0.55)
Output NTM				−1.528**	−1.577**	−1.062**
				(0.31)	(0.31)	(0.34)
Output MFN				0.084**	0.080**	0.049*
				(0.026)	(0.026)	(0.024)
Importer = 1		0.255**	0.255**	0.264**	0.255**	0.443**
		(0.078)	(0.078)	(0.079)	(0.078)	(0.079)
Exporter = 1					0.113**	0.103**
					(0.022)	(0.022)
ln(Employment)	0.016	0.011	0.011	0.007	−0.002	−0.030
	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.050)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,093	10,093	10,093	10,093	10,093	9,207
R^2	0.377	0.378	0.378	0.383	0.386	0.394

The dependent variable is the natural log of TFP estimated on the quantity-based sample of monoproduct firms using Levinsohn and Petrin's (2003) method. Robust standard errors are in parentheses. Model (6) uses a one year lagged values of all trade policy variables—input and output NTMs and MFNs.

+p<0.1, *p<0.05, **p<0.01.

effect for variable input MFN is consistent with other findings in the literature—a 1% reduction in input MFN tariff is associated with a 1.8% increase in productivity. The difference between the coefficients of input MFNs in models (3) and (4) can be explained by an omitted variable bias, as output and input tariffs are correlated with each other. In column (5) we control for exporting status. Exporters are 11.3% more productive than non-exporters. This corresponds well with the theoretical model of Melitz (2003), which asserts that only the most productive firms are able to cover the fixed costs associated with expanding into the foreign market. This has also been confirmed in many other empirical studies (see, e.g., Bernard et al., 2003). Finally, in column (6) we use a one-year lag for our policy variables because they may have a delay in influence. This step also reduces endogeneity concerns. However, lagging the variables of interest does not change the sign, nor the significance levels of the coefficients of the variable of interest—the interaction of importing and input NTMs in fact turns more negative. Output NTMs and input tariffs also remain strongly negative and significant.

To sum up, applying NTMs to the imports of intermediate inputs significantly lowers a food-producing firm's productivity. This result is robust to controlling for the effect of tariffs on intermediate inputs and the effect of trade policy on final outputs.

TABLE 5 NTM effects for different TFP measures

	OP		ACF		LP		LP-ACF	
	R	**Q**	**R**	**Q**	**R**	**Q**	**R**	**Q**
Input NTM	0.235	−0.759	0.270	1.655**	−0.174	0.897	0.467	0.103
	(0.49)	(0.58)	(0.49)	(0.56)	(0.49)	(0.60)	(0.49)	(0.56)
Input NTM × Importer	−0.412+	−0.561+	−0.390	−0.658*	−0.507*	−0.972**	−0.374	−0.583*
	(0.25)	(0.29)	(0.25)	(0.29)	(0.25)	(0.31)	(0.25)	(0.29)
Input MFN	−0.583	−1.149*	−0.930*	−0.054	−0.594	−1.935**	−0.764+	−2.033**
	(0.43)	(0.51)	(0.43)	(0.50)	(0.43)	(0.53)	(0.43)	(0.49)
Importer = 1	0.119*	0.157*	0.105+	0.148*	0.153*	0.255**	0.107+	0.158*
	(0.060)	(0.072)	(0.061)	(0.070)	(0.061)	(0.075)	(0.061)	(0.070)
Exporter = 1	0.102**	0.106**	0.096**	0.099**	0.105**	0.113**	0.094**	0.097**
	(0.015)	(0.018)	(0.016)	(0.018)	(0.015)	(0.019)	(0.015)	(0.018)
Output NTM	−0.323	−0.022	−0.518*	−0.272	−0.409*	−1.577**	−0.550**	−0.884**
	(0.20)	(0.24)	(0.20)	(0.23)	(0.20)	(0.25)	(0.20)	(0.23)
Output MFN	−0.055**	−0.101**	−0.032*	−0.027+	−0.032*	0.080**	−0.032*	0.001
	(0.013)	(0.015)	(0.013)	(0.015)	(0.013)	(0.016)	(0.013)	(0.015)
ln(Employment)	−0.056**	−0.054**	−0.128**	−0.292**	0.015	−0.002	−0.152**	−0.077**
	(0.012)	(0.014)	(0.012)	(0.014)	(0.012)	(0.015)	(0.012)	(0.014)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,093	10,093	10,093	10,093	10,093	10,093	10,093	10,093
R^2	0.093	0.155	0.042	0.469	0.266	0.386	0.046	0.147

The dependent variables in this table vary with the method of TFP estimation. OP is based on Olley and Pakes (1996), LP is based on Levinsohn and Petrin (2003), ACF and LP-ACF is based on Ackerberg et al. (2015). All TFP are estimated on the sample of monoproduct firms using either revenue measure of output (columns 1, 3, 5, 7) of quantity measure of output (2, 4, 6, 8). Robust standard errors are in parentheses. All models have firm fixed effects.

+p<0.1, *p<0.05, **p<0.01.

TABLE 6 NTM and tariff liberalisation and product characteristics

	Sanit.	Phyto	Veter	Ecolo	Cert	MFN
	(1)	(2)	(3)	(4)	(5)	(6)
ln (Output)	−0.095*	0.002	−0.013	−0.013	0.018	0.003
	(0.046)	(0.028)	(0.025)	(0.025)	(0.077)	(0.0038)
Observations	662	662	662	662	662	662
R^2	0.005	0.000	0.000	0.000	0.000	0.001
ln (Output)	−0.094	−0.011	−0.013	−0.013	0.028	0.001
	(0.050)	(0.037)	(0.027)	(0.027)	(0.096)	(0.0048)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	662	662	662	662	662	662
R^2	0.033	0.006	0.003	0.003	0.009	0.014
ln(Employment)	−0.075	−0.014	−0.023	−0.023	0.064	0.000
	(0.060)	(0.034)	(0.038)	(0.038)	(0.083)	(0.0047)
Observations	662	662	662	662	662	662
R^2	0.002	0.000	0.001	0.001	0.000	0.000
ln(Employment)	−0.057	−0.026	−0.028	−0.028	0.086	0.001
	(0.062)	(0.040)	(0.042)	(0.042)	(0.11)	(0.0054)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	662	662	662	662	662	662
R^2	0.030	0.007	0.004	0.004	0.009	0.014
ln(Number of firms)	−0.040	−0.004	−0.002	−0.002	0.029	0.000
	(0.028)	(0.013)	(0.017)	(0.017)	(0.050)	(0.0017)
Observations	662	662	662	662	662	662
R^2	0.003	0.000	0.000	0.000	0.000	0.000
ln(Number of firms)	−0.044	−0.012	−0.005	−0.005	0.041	0.000
	(0.030)	(0.015)	(0.016)	(0.016)	(0.060)	(0.0017)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	662	662	662	662	662	662
R^2	0.032	0.007	0.003	0.003	0.009	0.014
Industry concentration, HHI	0.438	0.031	−0.206	−0.206	0.103	−0.016
	(0.43)	(0.13)	(0.51)	(0.51)	(0.55)	(0.019)
Observations	662	662	662	662	662	662
R^2	0.001	0.000	0.001	0.001	0.000	0.000
Industry concentration, HHI	0.514	0.051	−0.203	−0.203	0.129	−0.014
	(0.42)	(0.13)	(0.49)	(0.49)	(0.56)	(0.018)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	662	662	662	662	662	662
R^2	0.030	0.006	0.004	0.004	0.009	0.015

Each cell represents a separate regression of a 5-year change in NTM or MFN tariff in 2008–2013 on the variable in the corresponding row. A unit of observation is an HS4 product, relevant variables are average output and employment of a firm, importing within HS4 product, number of firms and HHI index of concentration for firms importing HS4 product.
+$p<0.1$, *$p<0.05$, **$p<0.01$ Robust standard errors in parentheses.

6.2 | Alternative measures of productivity

We also consider different measures of productivity, including OP method and the Ackerberg-Caves-Frazer method (Ackerberg et al., 2015) applied to the Levinsohn–Petrin method of production function estimation (LP-ACF, see Levinsohn & Petrin, 2003). The results are presented in Table 5. We report TFP measured by the standard Levinsohn–Petrin method. In all cases, we estimate how NTMs influence revenue- and quantity-based TFP for mono-product firms. The results are relatively stable and consistent across all types of TFP: input NTMs have a negative effect on the productivity of importers when we measure productivity using a quantity-based production function. The effect is more pronounced for the quantity-based TFP measure because revenue-based TFP includes the positive effect of higher NTM protection on the prices of final goods, leading to a higher coefficient for input NTMs for all model specifications. Output NTM and tariff barriers to trade also tend to have a negative effect on firm productivity.

6.3 | Changes in trade policy and product characteristics

Trade policy is likely to be endogenous to trade structure and industry composition. For instance, superstar firms accumulate economic resources and political capital that are comparable to or even exceed the resources available in many developing countries. Such firms successfully lobby for trade policy negotiations to incorporate low tariffs, lax labour standards and preferential tax regimes (Rodrik, 2018). The ability of firms and industries to influence trade policy depends on their economic size, political connections or degree of coordination, leading to a biased coefficient in a regression of productivity on NTM.

However, these concerns are greatly reduced when the analysis concerns firms in the developing and transition countries. Ukrainian firms do not appear on the list of superstar firms. They lack the resources to be able to influence the WTO negotiations between Ukraine and its trading partners such as the EU and the USA, who are much larger in size and are lobbying for the interests of their own industries.[13] Nor were the Ukrainian food firms particularly well organised or coordinated, given that there were structural changes in the 1990s and 2000s, and the process of transitioning through these was not conducive to forming effective business associations. Frequent changes of government and the absence of adequately structured political parties did not offer firms fully functioning channels for lobbying for their economic interests. Therefore, trade policy changes are more likely to be exogenous.

This conjecture is confirmed by statistical analysis. Following Khandelwal and Topalova (2011), Movchan et al., (2020) present evidence that the trade policy changes in 2008–2013 were not driven by lobbying by local firms. In this paper, we reproduce these findings and also present new evidence on the independence of the policy changes from food industry market structure and political weight. Table 6 presents the results. Each cell is a separate regression of a 5-year change in NTMs or MFN tariff in 2008–2013 on the variable in the corresponding row. A unit of observation is an HS 4 product-year, the relevant variables are average output and employment, the number of firms, and the Herfindahl-Hirschman Index (HHI) of concentration of firms importing within HS 4 products. Results are presented with and without sub-industry fixed effects. In all cases, with the exception of the significant negative effect of log output on sanitary measures, changes in the trade policy variables cannot be explained by economic size or coordination complexity, or measured by the number of firms or HHI degree

[13]Ukrainian oligarchs who represented extractive industries were much more politically active, but the food industry is more competitive and less politically connected.

of concentration. Even in the case of sanitary measures, the impact of the economic size disappears, once we control for sub-industry fixed effects.

We conclude that there is no evidence that the trade policy changes related to food processing were driven by domestic industry lobbying. The Ukrainian WTO accession, which was the driving force of the changes to NTMs post-2008, was primarily shaped by trade policy changes imposed by such economic superpowers as the EU and the USA, who were concerned that their multinational companies and financial industries could benefit from good market access and services liberalisation (Shepotylo & Vakhitov, 2015). This result is reassuring because we can treat changes in NTMs and tariffs as exogenous shocks to domestic firms in Ukraine.

In order to address any remaining concerns about the endogeneity of selection into importers, we also consider regressions in 3- and 5-year differences. The results, which are presented in the Online Appendix, confirm that NTMs have a negative impact on productivity.

7 | CONCLUSION AND POLICY IMPLICATIONS

This paper argues that non-tariff measures applied to imported intermediate inputs lower the productivity of firms by restricting the variety of available imported inputs and distorting the efficient input mix toward domestic producers. We find that there is an overall negative effect of NTM on productivity—a 1% increase in NTM on imported inputs lowers the productivity of importing firms by 0.2%–1.7%. Other instruments of trade policy, including input and output tariffs and output NTMs, also tend to have negative effects on productivity.

The effect is heterogeneous and depends on the type of NTM. Using a unique database of sanitary, phytosanitary, veterinary, ecological and mandatory certification measures, we showed that sanitary and phytosanitary and ecological measures on imported inputs have a stronger negative effect on the productivity of those firms that used imported inputs more intensively prior to the episode of trade liberalisation in Ukraine in 2008–2012. Importantly, we find that the effect of all types of NTMs on quantity-based productivity measures is always more negative than the effect of NTMs on revenue-based productivity. This is consistent with our prior expectations that firms respond to stricter NTM regulations by adjusting prices upwards to soften the impact of trade policy on their performance. It is also consistent with the previous findings in the literature about the differences in the performance of quantity- and revenue-based productivity measures (Foster et al., 2008; Syverson, 2004). This finding also highlights the importance of properly measuring productivity for trade policy analysis. Other trade policy variables, such as input and output tariffs and NTMs on outputs, also tend to have negative effects on productivity. This result shows the importance of controlling for the effects channelled through changes in prices when estimating the effects of policies on productivity. In terms of policy implications, our results show that the negative effect of imposing NTMs on productivity should be taken into account when policy makers consider a policy to address legitimate public concerns about food quality and safety.

These findings indicate that public health and safety is more efficiently protected through the control of outputs rather than through the introduction of non-tariff measures on inputs. Also, it is more efficient to regulate and ensure product quality and safety through the control of production process (e.g., HACCP) because the requirement to certify equipment is less detrimental to productivity than a requirement to implement SPS measures.

We also demonstrated the importance of careful estimation of the production function because the revenue-based TFP confounds the physical productivity and price measures of productivity. NTMs have a consistently stronger negative effect on quantity-based TFP, while the effect on revenue-based TFP is attenuated by the change in price. This may be explained by the reaction of price and quality of output to changes in NTM. To analyse the effect on quality, more detailed data on imported inputs is required. We leave this question for further research.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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